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THESIS

SHARING INFORMATION AMONG VARIOUS ORGANIZATIONS IN RELIEF EFFORTS

by

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September 2005

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Today, information sharing is critical to almost every institution and organization. There is no more pressing need for information sharing than during an international crisis, where multi-national military-civilian coordination is formed. Successful information technology implementation for international crises could be increased by analyzing prior relief efforts. The purpose of this thesis is to explore the role of information technology in enabling the sharing of actionable information among various organizations in relief efforts.

At all levels of relief efforts, strategies to provide adequate help to the victims of disaster will rely on the development and distribution of actionable information. It is essential that participants strengthen their capacity to gather, share, analyze and disseminate such information. When using or developing information technology in relief operations, it is necessary to be aware of the obstacles related to information sharing. Due to the uniqueness of each relief operation, dependant on the various participants and nature of the disaster, it is difficult to define the problems, symptoms and possible solutions of each situation. Specifically, this thesis attempts to establish the requirements for the development of a Disaster Information Management System by examining both the universal problems in disaster relief operations and their possible solutions from within information technology.

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SHARING INFORMATION AMONG VARIOUS ORGANIZATIONS IN RELIEF EFFORTS

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LIST OF ACRONYMS AND ABBREVIATIONS

APAN	Asia Pacific Area Network
CA	Civil Affair
CSF	Combined Support Force
CSG	Combined Support Group
CHA	Consortium of Humanitarian Agency
CHE	Complex Humanitarian Emergencies
CMCB	Civil Military Coordination Board
CMOC	Civil Military Operations Center
CTF	Combined Tactical Force
DART	Disaster Assistance Response Team
DISA	Defense Information System Agency
DRN	Disaster Relief Network
ESB	Emergency Services Branch
FCSS	Field Coordination Support Section
HACC	Humanitarian Assistance Coordination Center
HIC	Humanitarian Information Centre
HN	Host Nation
ICTA	Information and Communication Technology Agency
IDP	Internally Displaced People
IO	International Organization
JOC	Joint Operation Center
JTF	Joint Tactical Force

MDM	Multiple Decision Makers
MLO	Military Liaison Officers
MNF	Multi-National Forces
MOOTW	Military Operations Other Than War
NGO	Non-Government Organizations
NIPRNET	Non-Secure Internet Protocol Router Network
NPS	Naval Postgraduate School
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
OFDA	Office of Foreign Disaster Assistance
OSOCC	On-Site Operations Coordination Center
POST	Peace Operation Support Tool
RFA	Requests for Assistance
RFI	Request for Information
UN	United Nations
USPACOM	US Pacific Command
VIC	Virtual Information Center

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I. INTRODUCTION

A. AREA OF RESEARCH

The purpose of this thesis is to explore the role of information technology that enables the sharing of actionable information among various organizations in relief efforts. An analysis will be done of how different organizations such as military, United Nations (UN) and Non-Government Organizations (NGOs) used information technologies, during the December 2004 Indian Ocean tsunami relief efforts, to increase the information flow across the organizations and thereby enhance the level of success of the operations. This thesis will determine the requirements for information systems at the operational level.

B. RESEARCH QUESTIONS

Pertinent questions that will be addressed by this thesis include:

- How is information technology (IT) used to increase information flow across numerous organizations in relief efforts?
- How was IT, which supports information flow, supposed to work in the Indian Ocean tsunami relief efforts?
- How did it really work?
- What are the issues that affect or impact the interface among the military, International Organizations, Non-Government Organizations and affected countries during relief efforts?
- What are the requirements for information systems at the operational level, in order to increase operation's success?

C. MOTIVATION

Today, information sharing is critical to almost every institution and organization. There is no more pressing need for information sharing than during an international crisis, where multi-national military-civilian (such as UN and NGOs) coordination is formed. Successful information technology implementation for international crises could be increased by analyzing the relief efforts and by creating lessons learned. This thesis could provide a concept of using information technology in relief efforts; therefore, military and civilian organizations--which do not have and do not want to develop systems in their organization--could have insight about operations and requirements for desired collaboration among participants in relief efforts. This could be of the utmost importance, especially for those countries that might become involved in natural disaster or humanitarian relief operations due to nature their geographical or political situations. This thesis could provide information about issues of which developers of the system that assists humanitarian operations should be aware.

D. METHODOLOGY

The methodology that will be used to produce this thesis includes the following:

- Conduct a subject-matter search of books, periodicals, knowledge bases, and other library information services describing networks and collaborative and database technologies that are used during relief efforts by various organizations.
- Collect data from participants in the December 2004 Indian Ocean tsunami relief operations, such as:
    - US Pacific Command (USPACOM) Defense Information System Agency (DISA), which set up a Tsunami Operation Cell to provide communication and information systems support to Combined Support Force (CSF) 536, formerly known as JTF 536.
    - United Nations Office for the Coordination of Humanitarian Affairs (OCHA), which uses modern internet technology such as:
        - Virtual OSOCC (On-Site Operations Coordination Center) - provides an effective tool to facilitate the information exchange between responding governments and organizations throughout the relief operation
        - ReliefWeb - online gateway to information on humanitarian emergencies and disasters

    - Consortium of Humanitarian Agencies (CHA) and Information and Communication Technology Agency of Sri Lanka (ICTA), which created the information databases (Sahana) to "better coordinate the relief efforts of the roughly 13,000 NGOs that are operating in Sri Lanka."

- Analyze information technologies used during the December 2004 Indian Ocean tsunami relief efforts and assess their effectiveness.
- Determine the requirements for an information management system at the operational level, based on the analysis.

E. LIMITATION AND ASSUMPTIONS

The scope of this thesis is not to define the roles of the participants in peace operations or relief efforts (who does what, when, where...who leads?); instead, it is to identify how they use IT in order to establish communication and an information-sharing environment, and how they increase the level of success of the operations. Three levels of collaboration between organizations will be discussed. According to current information-sharing technologies used among the various organizations, the achieved levels of collaboration will be examined.

By using the qualitative method as the research method and the December 2004 Indian Ocean tsunami relief efforts as the case study, requirements determination will be conducted by analyzing the participants' technology use in these relief efforts. Covering all information technologies that supported information sharing among all participants of the December 2004 Indian Ocean tsunami relief efforts is beyond this thesis' boundary. Therefore, some key players of these efforts--PACOM, OCHA and some governments--will be covered to understand how IT has worked in relief operations.

F. THESIS ORGANIZATION

This thesis consists of five chapters: introduction, motivation and overview; background and related work during relief operations; literature review of military and civilian information technologies that support information sharing among organizations and discussions about how those technologies were used in the 2004 tsunami relief operations; operational/field level problems and local IT community participation; information management requirements; and conclusions.

II. BACKGROUND AND RELATED WORK

A. RELIEF OPERATIONS

In general, relief operations are humanitarian operations conducted to relieve human suffering, especially in circumstances where responsible authorities in the area are unable or unwilling to provide adequate service support to civilian populations [1]. From the military perspective, relief operations fall in the area of Military Operations Other Than War (MOOTW) as Humanitarian Assistance, which is described in Joint Doctrine for MOOTW. They are operations that relieve or reduce the result of natural or manmade disasters or other endemic conditions such as pain, disease, hunger, or privation in countries or regions outside the United States.[2] Figure 1 shows relief operations within the range of military operations.

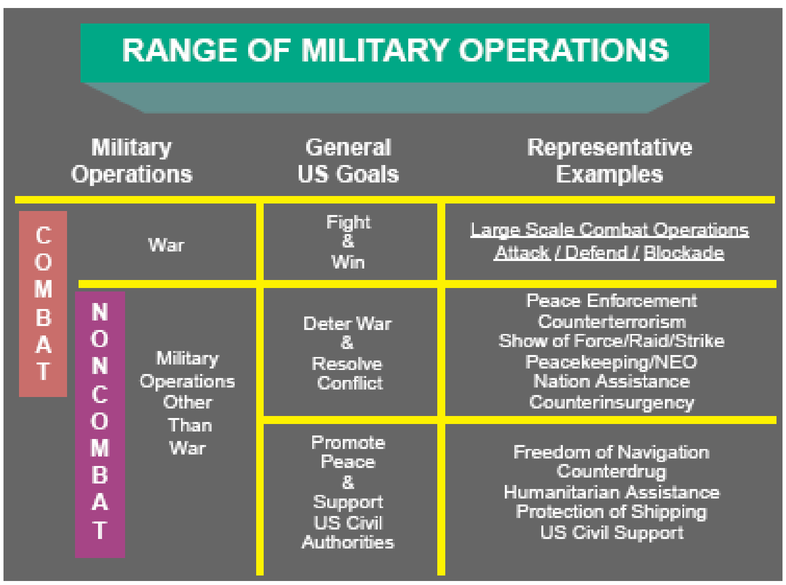

Figure 1 Range of Military Operations. (From Ref. [2])

When relief operations are examined from the perspective of military and NGO, it is seen that humanitarian operations should be temporarily executed until the host nation agencies establish their responsibilities in the disaster area. Because of that, providing services and aid is not the only consideration during the relief operation; another factor is how those activities are conducted. Humanitarian members, who are made up of people with very different personal motives and professional backgrounds, and who have varying organizational structures, should be aware of the nature of the relief operation and should know the other members in order to achieve success at both relief and post-relief efforts.

Basic efforts related to relief operations in the aftermath of an earthquake are [4]:

- The immediate reaction is to move as many people to safety as possible, an action that is usually executed by a military because the military possess a rapidly deployable lift capability with helicopters and all-terrain vehicles.
- At a certain point in the relief efforts, the emphasis shifts toward housing and protecting the displaced people. This responsibility can fall on several organizations. United Nations units and host nation agencies usually provide shelter (tent village), clothing, food and protection to Internally Displaced People (IDP) in organized camps**.**
- Water is initially supplied by a bottled-water company and delivered by military transport.
- Engineering teams are required for construction and plumbing support to these camps in an attempt to provide a minimal comfort environment, until more permanent facilities can be established or the camp is not needed.
- Eventually, there is a recovery phase, which includes cleanup and rebuilding basic infrastructure to get the region operational.

Those efforts require exchange of valuable information for operations and collaboration among humanitarian members.

B. ACTIONABLE INFORMATION

Unarguably, information provides insights and answers needed to succeed for individuals from different organizations and from various levels within those organizations. With respect to information, below are needs to fulfill key-player organizations' objectives and to do their jobs [3].

- Access to data in useful format when and where needed
- Ability to adapt to changing operational needs

- Accurate and consistent data
- Share data across the organization
- Contain costs

Actionable information for relief efforts must not be buried in a haystack of other, irrelevant data. Faced with the circumstance of many people suffering a lack of their basic needs such water and shelter, investing in information technology that has a high price may not be considered a reasonable decision for the authorities, given the possible reaction from the disaster victims. Therefore, the cost of pulling and pushing information is the driving factor for relief operations, as it is seen in the many areas where information technology is used.

C. COLLABORATION

As its Latin roots *com* and *laborare* suggest, collaboration reduced to its simplest definition means "to work together." The search for a more comprehensive definition leads to “a temporary social arrangement in which two or more social actors work together toward a singular common end that requires the transmutation of materials, ideas, and/or social relations to achieve that end.” [5] There are three levels of collaboration [6]:

Level 1: Individuals who are not part of a working group or team operate independently and interactively to pass documents back and forth to accommodate their own specific needs.

Level 2: Individuals with common interests operate at collaboration to exchange information, but not to achieve a common goal.

Level 3: Collaboration involves participants working as a team to achieve a common goal.

These levels of collaborations will be examined in the following chapters in terms of the information technology used in tsunami relief operations in the Indian Ocean in 2004.

D. DECISION MAKING

Many different types of decision makers, such as individual decision makers and multiple decision makers (MDM) must be supported in the many different types of problem contexts. Information flow among various members becomes an important issue in relief operations where multiple individuals interact to reach a decision. There are three main MDM structure defined by Marakas: Group, Team and Committee (or Individual). The classifications of these structures are based on the degree of relevance of non-decision makers' interaction to the final product. In this sense, group structure is classified as "collaborative structure," whereas others are classified as "noncollaborative." [7] Figure 2 illustrates each of the main MDM structures.

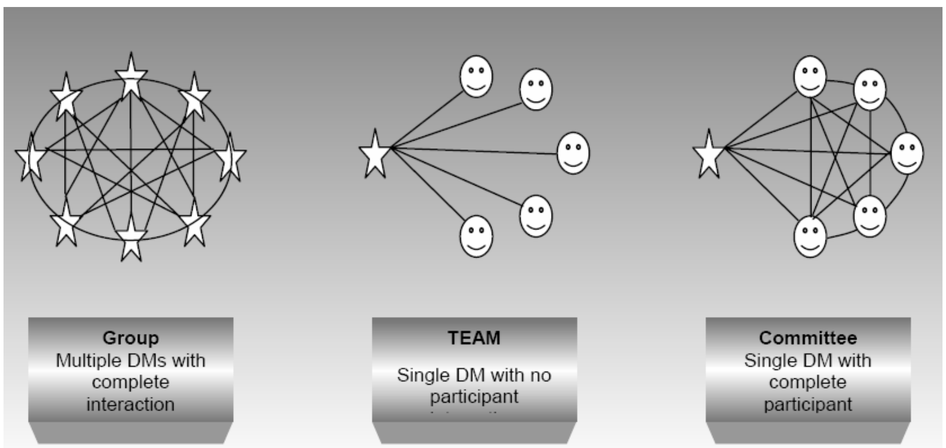

Figure 2 Basic MDM Structure (From Ref. [7])

It is the group structure that best fits the problem context of relief operations that can be considered as a sub-operation of Complex Humanitarian Emergencies (CHE), with independent organizations with no hierarchy or structure for interacting, with the exception of a common overarching vision to collaborate and share information [8].

E. ORGANIZATIONAL CULTURE

Organizational culture is defined by Edgar Schein as a system of shared meaning consisting of beliefs, symbols, rituals, myths, and practices that have evolved over time.[7] Success of the organizations is related to the good fit between their cultures and their external and internal environments. Organizational culture comprises the leadership and management styles, decision-making procedures, politics, attitudes and formal and informal communication of the organization. If the culture fits with the relief operations environment, then the organization has a better chance of succeeding. Comparison of organizations in relief operations could be another thesis research topic beyond this thesis. At least, it is necessary to mention the characteristics of the organizational culture and differences of two distinct participants of relief operations: military and NGOs.

1. Characteristics of Organizational Culture

Robins identified ten elements that, when mixed together, define a particular organization culture. Table 1 lists these 10 characteristics of organizational culture:

1. Individual Initiative	The degree of responsibility, freedom, and independence that individuals have
2. Risk Tolerance	The degree to which employees are encouraged to be aggressive, innovative, and risk seeking
3. Direction	The degree to which the organization creates clear objectives and performance expectations.
4. Integration	The degree to which units within organizations are encouraged to operate in a coordinated manner
5. Management Support	The degree to which managers provide clear communication, assistance and support to their subordinates
6. Control	The number of rules and regulations, and amount of direct supervision, that are used to oversee and control employee behavior
7. Identity	The degree to which members identify with organization as a whole rather than with their particular work group or field of operational expertise
8. Reward System	The degree to which reward allocations are based on employee performance
9. Conflict Tolerance	The degree to which employee are encouraged to air conflict and criticism openly
10. Communication Patterns	The degree to which organizational communications are restricted to formal hierarchy of authority

Table 1. Ten Characteristic of Organizational Culture. (From Ref. [9])

Within these characteristics, various combinations are critical for different phases of relief efforts, such as individual initiative, integration and communication patterns, which are important during the initial phase of relief operations. For instance, OCHA responds quickly for humanitarian operations because of the degree of independence that UN units possess; also, the communication patterns of UN units are less restricted than those of other organizations, especially less than those of the military.

2. Military-NGO Cultures

The following table produced by the Center for Disaster Management and Humanitarian Assistance illustrates the differences between military and NGO cultures:

NGO	Military
Independent	Highly Disciplined
Decentralized Authority	Hierarchical Command
On-The-Job Training	Extensive Branch Training
Few Field Manuals	Doctrinal Publications
Long Term Perspective	“End State” approach
Field Experience	Combat Experience

Table 2. NGO Culture Contrasted with Military Culture (From Ref [9])

It is possible to understand the expected roles and limits of the military and NGO organizations, and related issues, resulting from the differences mentioned in Table 2. For example, one of the issues relating to differences in experience levels is a lack of trust, which results in military organizations first setting up security precautions within the operation environment. Another issue is the level of experience for military organizations. Even though the US military, for example, is involved in many humanitarian operations around the world, such operations do not form the primary experience for military personnel, as shown in Figure 1. Their training is more likely to deal with combat operations rather than non-combat, MOOTW. Level of experience with relief operations is a critical issue for establishing information flow between military organizations--especially those of developing countries--and civil organizations.

F. OBSTACLES TO SHARING INFORMATION

When using or developing information technology in relief operations, it is necessary to be aware of the obstacles related to information sharing. Due to the uniqueness of each relief operation, dependant on the various participants and nature of the disaster, it is difficult to define the problems, symptoms and possible solutions of each situation. Obstacles to sharing information can be attributed to many factors, such as organizational and cultural divides, different professions, and lack of network support [8]. The language barrier in multinational operations is another obstacle that affects the success of relief efforts.

Determining all problems related to relief operations that are the sub operation of Complex Humanitarian Emergencies are beyond this thesis' scope. The competing priorities and perceptions of participants are driving factors that must be understood. Because various participants that contribute to a given relief operation bring different priorities and perceptions, aligning missions and goals becomes a more challenging issue [8]. The technologies used in relief operations that will be mentioned in the next chapter should be analyzed in terms of those factors.

G. SUMMARY

At all levels of relief efforts, strategies to provide adequate help to the victims of the disasters will rely on the development and distribution of actionable information. It is essential that participants strengthen their capacity to gather, share, analyze and disseminate such information. These efforts may be jeopardized by a failure to adequately understand the nature of the relief operations, and by cultural impediments of participant organizations to building more effective information systems.

It is mentioned that due to the nature of the relief operation, it is necessary to have group MDM structure and the information technology that supports this structure. This leads to the interaction between various organizations and characteristics of the organization, which define the organizational culture. Therefore, organizational culture becomes a serious subject for relief operations.

The goals of both military organizations and NGOs in relief operation are temporary and should be ended when the host nation provides the necessary help and establishes the required authority in the disaster region. With respect to the information technology used in the relief efforts, the transfer of the mission to the host nation agencies and organizations is a vital concern. The host nation should continue the assistance without the help of the information technology provided by foreign military and international organizations. Because of that, all requests from the affected area should be checked very carefully with regard to the host nation's capabilities, and any response should be provided as much as possible by host nation agencies and organizations. This factor will be examined in further chapters.

III. INFORMATION TECHNOLOGY IN RELIEF EFFORTS

A. INTRODUCTION

On 26 December 2004, an earthquake originating in the Indian Ocean, and measuring 9.0 on Richter scale, caused a powerful tsunami that devastated the shores of Indonesia, Sri Lanka, South India, Thailand and other countries. It caused serious damage and death as far as the east coast of Africa. The number of affected counties was larger than those nations actually hit by the tsunami, in terms of the huge number of citizens from other countries who were also lost. Both individuals and organizations have brought different experience, knowledge, and technology to the region and relief operations.

Chapter II covers only a few aspects of the relief operation. The complexity of the operational environment increases when detailed analysis of human factors such as political relationship among the relief nations, and of events such as human or drug trafficking, are factored in. Therefore, it is not possible that information technology used in relief operations can provide all needs for the humanitarian members. This thesis does not seek the solution within the information technology domain that might cover all problems in relief operations; instead, it examines the technologies that were used in the 2004 Indian Ocean tsunami disaster and seeks the available technologies that might increase information flow among various organizations.

B. ENABLING TECHNOLOGIES

Information sharing for relief operation is dependent on communication systems. Without communication, terms such as information exchange and coordination cannot be used. In order to understand information technologies that support both military and civilian organizations in particular, first, it will be mentioned communication technology in general. Then, it will be discussed important information technologies used by various organizations and agencies such as the Civil Military Operation Center, On-Site Operations Coordination Centers and the Humanitarian Information Center.

1. Communications

It is very likely that a region's communication systems can be affected as much as its people by a disaster. It is a fact that if humanitarian members cannot communicate with each other and the people in the affected region, then they cannot deliver relief where it is most needed. Communication, such as communication inside the IDP camps and between governments and foreign military headquarters, is necessary at both the tactical and strategic levels. A wide range of communication equipment provided by various organizations--such as VHF and UHF radios and satellite phones--are used in relief operations. Communication equipment needed to do the job does not have to be complex.

a. Communications During 2004 Tsunami Relief Efforts

In Chapter II, it is mentioned that the nature of relief efforts requires a MDM structure, which means that communication systems provided by different organization should allow interaction among multiple decision makers from different organizations. From the many efforts to establish communications during the 2004 tsunami relief efforts, some of them could be highlighted in order to gain a general insight into the matter. For example, the International Telecommunication Union (ITU) sent 14 satellite terminals to Sri Lanka [11] and made 15 satellite earth stations available for emergency deployment to help coordinate the massive relief effort [12]; video telecommunication equipment was installed by the US Air Force for commanders of units in Indonesia, Sri Lanka and Thailand in order to improve communication[13]; and Smart Communications, Inc (SMART) immediately deployed 150 satellite phone kits to Indonesia, India, and the Maldives and provided satellite services[14].

The needs of the communication environment in refugee camps and information centers was provided by different vendors and established by volunteers or organizations. Naval Postgraduate School (NPS) participated in one of these efforts and helped establish communication among humanitarian members. The NPS team developed a hastily formed network at Phuket and Khao Lok in Thailand that provided a valuable wireless networking tool, and allowed disaster relief workers and refugees access to the Internet at high speeds from anywhere in the network area. Figure 3 shows the network architecture used in the Bang Moung refugee camp and processing center. The local WLAN and Internet access were available on 15 and 24 January 2005, respectively [15].

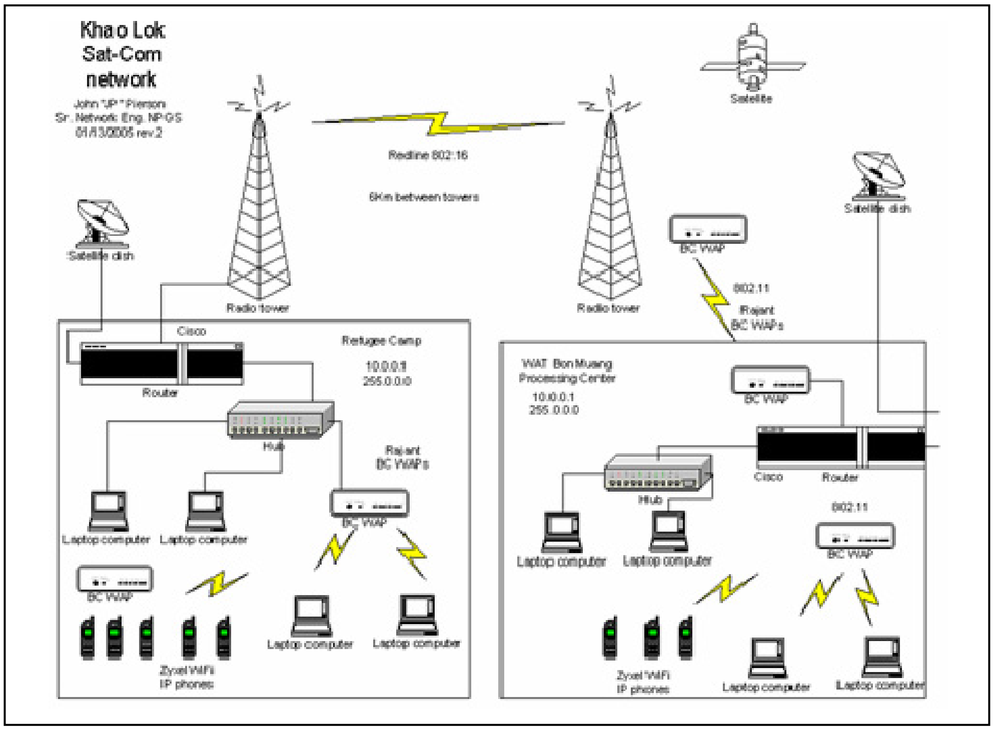

Figure 3 Network Architecture Bang Moung Refugee Camp (From Ref [15])

b. Discussion

The technology exists to establish required communications among the participants in humanitarian operations. Political will is needed to apply information and communication technologies in innovative and cost-effective ways for disaster reduction. Because the 2004 Indian Ocean tsunami affected large areas, and influenced many people, it was not possible to establish the desired communication networks in only a few weeks. Communication systems and roads, as well as people, were affected in the region. Establishing desired communication networks required the physical transfer of hardware into the region. People also were needed to configure networks. Even though many companies such as Cisco provided some hardware, problems such as missing cable, lack of power, and incompatible power cords also extended the time needed to configure a communication network. As mentioned in previous chapters, the solution provided by those agencies was temporary; the information management system for disaster relief should be designed with that fact in mind, and the designer should be aware of those technologies as well as possible problems.

After three months, there was a need for professionals to establish and manage the networks for refugee camps, which indicates a problem in the communication technologies. It was published that volunteers who were equipped with computer skills (basic knowledge of MS Office, Windows XP, Internet Explorer and overall usage of a PC) were needed for the setting up of Information Technology Centers in more than 40 of the largest refugee camps in Sri Lanka [16]. This was one of the limitations that caused a lack of access to actionable information and, most importantly, a failure in collecting data from the end users--volunteers, refugees, and humanitarian members--by using the World Wide Web. The efforts such as the NPS participation also raised lifecycle issues such as training, who takes over the network and who owns the devices in the end [15]. Overall, it was unrealistic to expect the creation of communication network that would enable a camp-level information-sharing environment for the entire affected area, even after a long period of time. On the other hand, the networks established for limited camps improved the effectiveness of ongoing efforts.

2. Military Technologies

To overcome the information-sharing difficulties of various coordination mechanisms, arrangements are developed by military organizations. Because of the fact that these mechanisms vary depending on the nation of the military organization, as well as on the branch of military unit, it may not reasonable to mention all of them that participate in humanitarian operations. Some of them are the Humanitarian Assistance Coordination Center (HACC), which is considered to be a planning and coordinating body that defines the strategy and develops an early assessment of a Humanitarian Operation; the Humanitarian Operation Center, which is primarily an international and interagency policy making and coordinating body; and the Civil Military Operations Center (CMOC), which performs liaison and coordination between the military support structure, NGOs and private organizations, other agencies, and local authorities [2].

Technologies that support those coordination mechanisms also vary. The CIMILink concept, Virtual Information Center (VIC), Peace Operation Support Tool (POST) concept and APAN CMOC are four of the DOD-initiative projects that have been designed for humanitarian operations [8]. U.S PACOM used the VIC and APAN CMOC during the 2004 tsunami efforts. Lotus Sametime collaboration tool that was provided by APAN during relief efforts will also be discussed.

a. VIC, APAN CMOC and Sametime

The Virtual Information Center (VIC) is a six-person cell that conducts research among public domain materials for the CDR U.S. Pacific Command (USPACOM) and his staff. The assessments generated by the VIC's researchers are disseminated to the headquarters staff and many other recipients as part of the VIC's situational-awareness mission. The VIC's products are intended to provide a public domain perspective on events and developments that the VIC staff feels may affect the Asia Pacific Region.[17]

The first actual application of the APAN CMOC, known initially as the "Virtual CMOC" [8] was as part of the operational exercise environment of the Combined Task Force. The Asia Pacific Area Network (APAN) is developing the APAN Civil Military Operations Center (CMOC) project. It is designed to meet a theater operational information exchange requirement, which emanates from the traditional functions of the CMOC. The mission of the APAN CMOC is to enable the CMOC staff of a deployed Joint Tactical Force (JTF) or Combined Tactical Force (CTF) to have access to and collaborate with civilian agencies. This is accomplished by providing a web portal and collaborative operational environment, using the Asia Pacific Area Network as a regional unclassified communications network. One function of APAN's role as PACOM'S unclassified engagement network is to act as a bridge between the CTF, with its restrictive classified communications local area network (LAN) and unclassified NIPRNET accessible only to US DOD personnel, and the uncleared community of humanitarian organizations that are also contributing to the relief efforts [18].

APAN also provides collaboration tools such as Lotus Sametime for humanitarian members via its web site. By using Lotus Sametime, relief members have opportunity of:

- Sending instant messages and transferring files to other relief members in real time
- Communicating with computer audio and video
- Editing shared files and saving changes
- Sending Web pages and poll questions to meeting participants
- Recording meeting such as camp coordination meeting so that other camp manager can view it later

Table 3 shows hardware and software requirement for Lotus Sametime [[19]]:

Server Side	Client Side
CPU: Pentium® II 400MHz (or higher)	**CPU:** Pentium II 266MHz (or higher)
Operating system: Windows® 2000 with Service Pack 2	**Operating system:** Windows 2000 Professional SP2 and Windows XP
Memory: Windows 2000: 1 GB RAM recommended; 512MB minimum	**Memory:** 128 MB RAM or higher for Windows 2000 Professional or Windows XP
Disk space: 1GB+ free disk space recommended to allow space for meetings; 500MB minimum	Not specific
Disk swap space: 64MB	Not specific
Browser: Microsoft Internet Explorer 6.0 or Netscape 7	**Microsoft Internet Explorer 6.0**: Sametime clients can operate in a Microsoft Internet Explorer 6.0 browser running its native Virtual Machine (VM) or the Sun Microsystems Java VM 1.4.1 (and the 1.4.1 Java Plug-in). **Netscape 7**: Sametime clients can operate in a Netscape 7 browser that uses the Sun Microsystems Java VM 1.4.1 and Java Plug-in 1.4.1. By default, Netscape 7 includes JVM 1.4.0, which is not supported by Sametime. Netscape 7 users must manually install the Sun Microsystems JVM 1.4.1 (and 1.4.1 Java Plug-in) to use Netscape 7 browsers with Sametime.

Table 3. Lotus Sametime Server and Client Side Requirements

Other requirements for features used in Lotus Sametime are:

Network Software: TCP/IP network software installed

Audio Requirements:

- Sound Card: Full-duplex sound card
- Microphone and Speakers: A high-quality microphone and speakers are recommended.

Video Requirements: No special software or hardware is required to receive video, but the following are needed to send video:

- Video-Capturing Software: Video for Windows
- Camera: A high-quality Universal Serial Bus (USB) or Personal Computer Memory Card International Association (PCMCIA) PC camera.

b. VIC and APAN CMOC at 2004 Tsunami Relief Efforts

These technologies were used in the U.S. military relief effort, which was named “Operation Unified Assistance” and announced at Hawaii, PACOM on 5 January 2005. The structure of the coordination headquarters was a Combined Support Force (CSF-536, also known as JTF-536) located in Utapao and three Combined Support Groups (CSGs), in-place in Indonesia, Sri Lanka and Thailand [20]. They worked hand-in-hand with the Office of Foreign Disaster Assistance (OFDA), a branch of the US Agency for International Development (USAID). OFDA deployed Military Liaison Officers (MLOs) with the OFDA Disaster Assistance Response Team (DART) that was responding to the relief efforts. The MLOs helped validate, coordinate and prioritize requests for assistance (RFAs) from the international humanitarian community and affected countries, under the direction of the DART team leader [21].

“Tsunami Hits South and Southeast Asia--A Special Press Summary,” which contained information about the impacts of the tsunami in terms of countries, and the global response/relief efforts by donor countries, was prepared by VIC staff almost on a daily basis. In addition, general information about the affected countries such as geography, people, government, etc., and the ability to make enhanced searches about several categories were provided on each country's home page (Figure 4). Dissemination of such information was used to increase the awareness of the both military and civilian members of the relief operation.

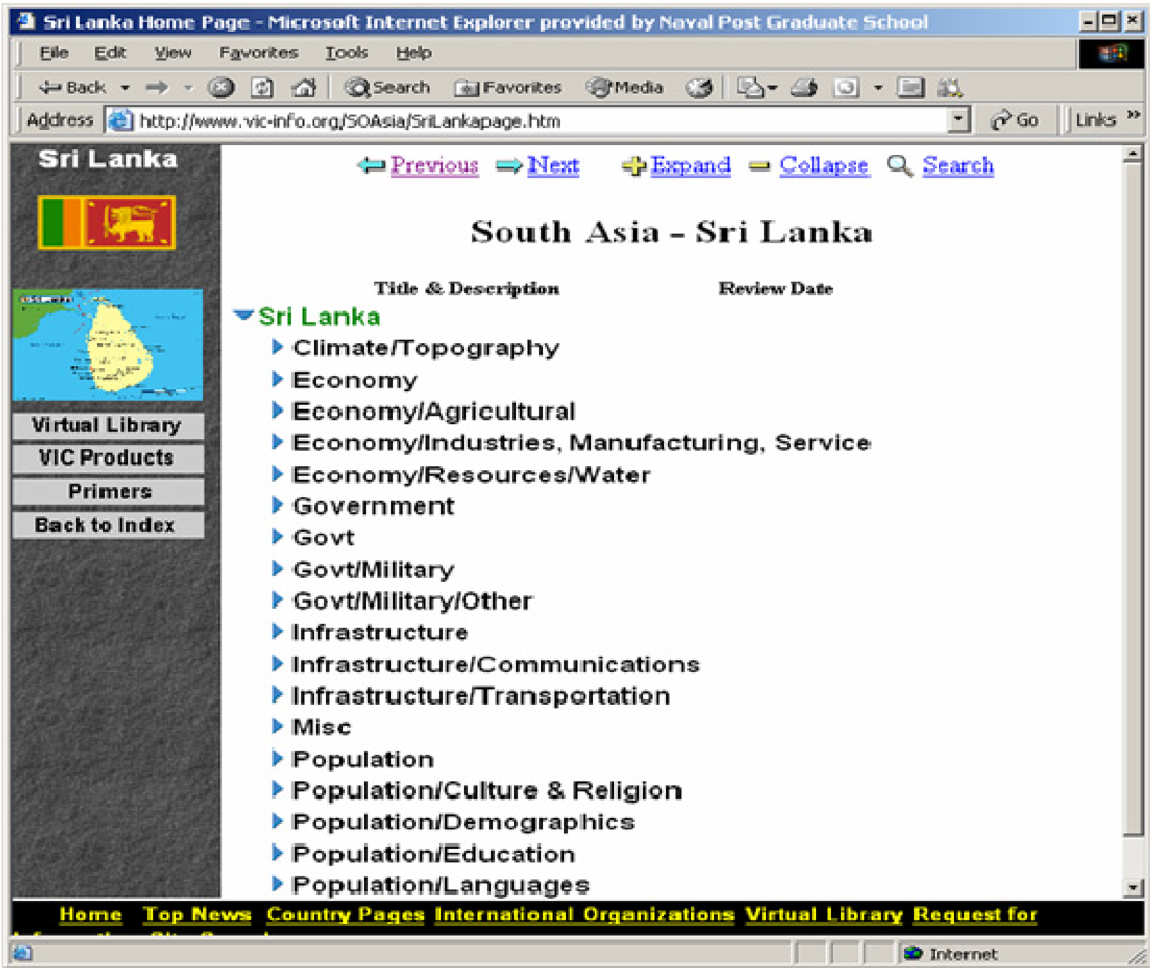

Figure 4 Example of VIC Country Sub Page

PACOM established a web-based Civil Military Operation Center (CMOC) under Asia Pacific Area Network in order to provide an easy-to-use tool for people to assist in a given geographic area (Figure 5). The goal was to match validated humanitarian needs to resources available from government organizations, non-government organizations and individuals. The needs were identified by several entities, such as Host Nations (HN), Multi National Forces (MNF), NGOs, International Organizations (IO) and Civil Affairs (CA) teams.

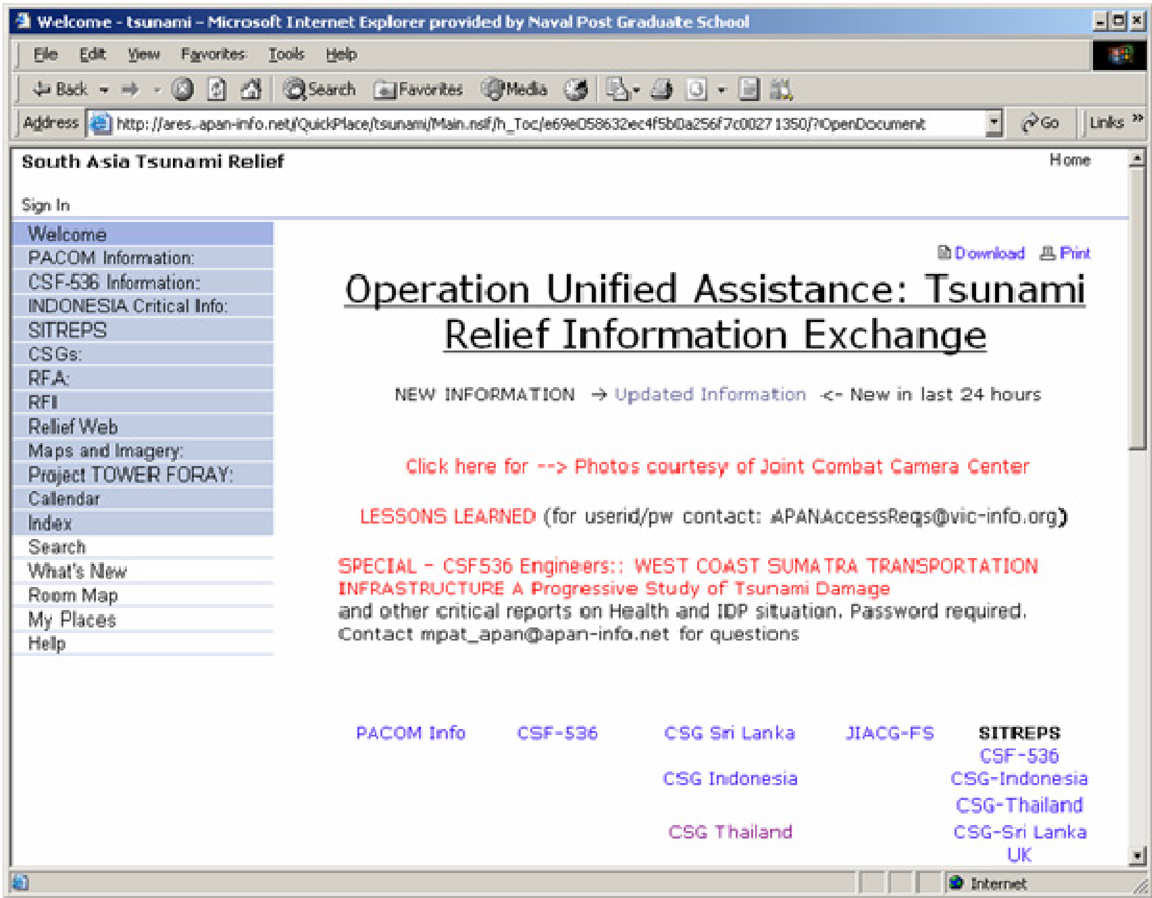

Figure 5 APAN CMOC for Operation Unified Assistance

The main functionalities provided by the APAN CMOC were situational reports, mostly on a daily basis; procedures and forms for requests for assistance (RFA) and requests for information (RFI); maps and imagery in different categories for affected areas; and quick links for humanitarian resources. Effective 14 February 2005, CSF 536 ceased operations in the tsunami-affected countries. Disaster assistance provided up to the closing date were 67 Recon Assessment sorties, 1328 fixed-wing flights, 2222 helicopter flights and 22,504,651 lbs. of relief supplies and equipment delivered to the region [22]. The most critical issue during this period was analyzing the urgency of each assistance request, and following the process that would identify the best way to respond to it.

In order to facilitate the processing of a request for support to CSF-536 or the CSGs, a requestor needed to fill out completely the data on an Excel spreadsheet, in the format specified by the APAN CMOC. Then it was sent via email to the

OFDA/DART Military Liaison Officer, where it was validated that the requirement could not be more efficiently filled by civilian relief organizations or the host nation. Any RFA that could not be supported at the CSG level or that was sent to CSF via other means was consolidated at the Civil Military Coordination Board (CMCB), which was a coordination mechanism having staff from international relief agencies, OFDA, Civil Affairs, and CSG liaisons. The CMCB would meet as needed to translate an RFA into standard format and transmit, with suggested priority, to the Joint Operation Center (JOC). If approved, the RFA was tasked to CSF directorates, as applicable, for sourcing. The basic request process is shown in Figure 6.

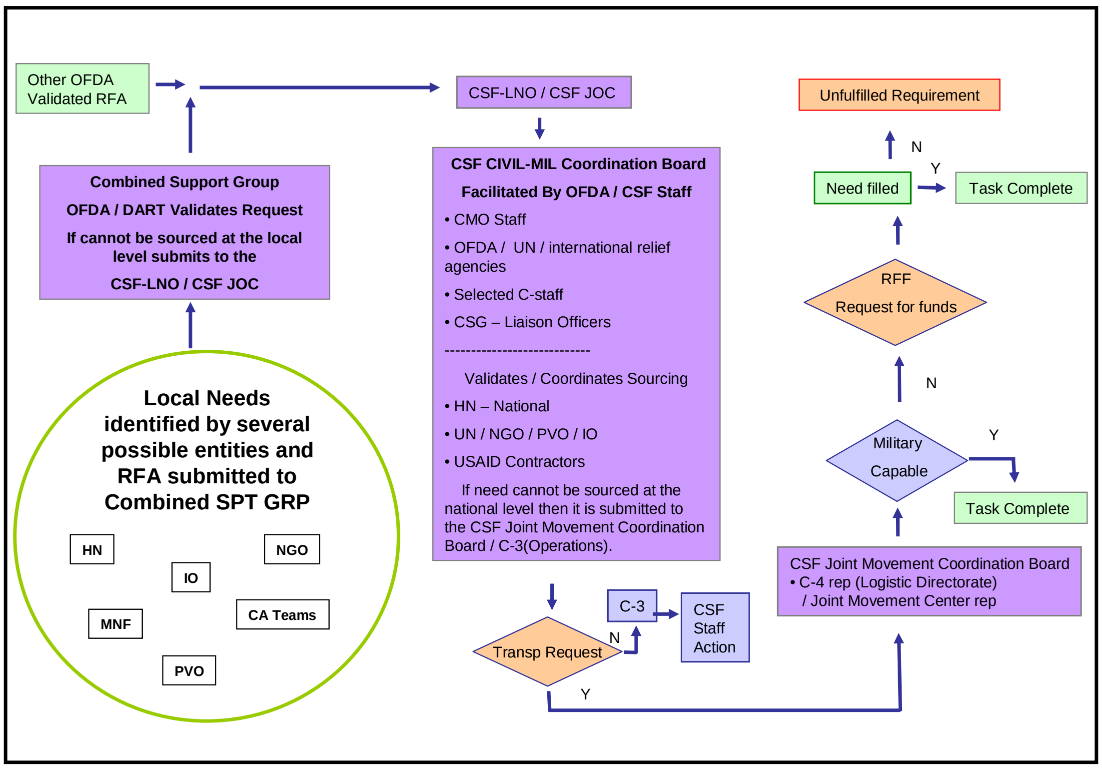

Figure 6 Request for Assistance (RFA) Process (After Ref [21])

As expected, most of the requests were related to transportation because of the airlift capability of the military. The requestor could track an RFA's status from the RFA report that was published on a near-daily basis in the APAN CMOC. Below are some statuses that were seen during the RFA process [22]:

- Requestor canceled RFA
- Review unit could not verify the requirement
- Closed due to no action taken
- Task Completed

c. *Discussion*

Among the characteristics of organizational culture mentioned in Chapter II, integration, which is the degree to which units within an organization are encouraged to operate in a coordinated manner, is crucial to the RFA process. Quick validation of the requests depends on the collaboration of the CSG staff, CSF staff, members of the CMCB and many other entities. The least capability that requestors needed during the RFA process was access to the form that was formatted as an Excel spreadsheet, and the email capability to send it to the DART. Combined with the tracking capability, it can be seen that level 1 of collaboration was achieved by the APAN CMOC, and level 3 of collaboration was achieved by the process itself.

The ability to find local solutions, or the closest units that could fill local needs identified by different entities, was the key concern for the RFA process. The request validation needed to include information about the region, the working humanitarian groups within that region, and the type of support that humanitarian groups could provide, but most importantly information related to the capability of the host nation's military and civil agencies. VIC provided only limited information regarding the required information mentioned above, and APAN CMOC had only links to ReliefWeb and VIC to lead a requestor to that information.

Lotus Sametime, collaboration tool provided by APAN, was used during Indian Ocean tsunami Relief Operations. Relief members from different sectors were able to register and use Lotus Sametime. It enabled relief members to schedule and search meetings related to their sectors, district or country, share and make change to documents. One of the drawbacks was that Sametime required using certain operating systems (windows) and configuration. Therefore, it reduced usage of Sametime by some relief members. Getting actionable information from field and eliminating process requests which could be provided by locally were required that Sametime should have been used more by local community. In order to increase coordination among host nation agencies and organizations, it was necessary to use capability to support multi languages. Even though Sametime supported multiple languages, it was observed that this capability was not used by relief members. Over all, Lotus Sametime provided some level of collaboration among relief members; however, it did not serve as much as needed because of lack of participation.

The assistance provided by the CSF and CSG was a very small piece of the overall relief and post-relief operations; however, they enhanced the support capabilities of other agencies in their aid to the tsunami victims. The technology provided and used by military organizations during the Indian Ocean tsunami relief operations increased the information flow among various organizations; however, there were many factors that also influenced it. The remaining part of this chapter will mention the other half of the equation: technology used by civil organization and its effect over information flow.

3. Civilian Technologies

Civilian coordinating mechanisms are similar to military mechanisms in terms of providing information sharing among humanitarian members. Due to different roles in relief operations, civilian mechanisms may include different entities than the military mechanisms. The United Nations (UN), especially the UN Office for the Coordination of Humanitarian Affairs (OCHA), have participated in many humanitarian operations worldwide; thus, mechanisms such as the On-site Operation Coordination Center (OSOCC) and Humanitarian Information Centre (HIC) used by the UN are key components of the civilian side of the relief operations.

The OSOCC is one of the early coordination tools used by the UN to do many of the same functions that the HOC and CMOC accomplish. The United Nations Disaster Assessment and Coordination Team (UNDAC), working under OCHA, generally establish an OSOCC as soon as possible following a major disaster. The OSOCC provides a rapid assessment and coordination capability during the initial stages of a disaster. HIC works to guarantee an on-going exchange of information concerning security, humanitarian activities, communications, sector assessments, requests for humanitarian aid assistance, and requests for use of UN assets. HIC provides the vital function of collecting, analyzing and disseminating information; therefore, it serves to focus individual efforts where they are needed most. The HIC also supports the decision-making process at the headquarters and field level by contributing to the creation of a common framework for information management within the humanitarian community [8] [25].

The technologies that are used by the UN to fulfill the same functionality of OSOCC and HIC are ReliefWeb, the Virtual OSOCC (also known as Virtual Operations Coordination) and the HIC web sites prepared for each country in which the humanitarian operations is involved. The opportunity to gather and disseminate actionable information for the humanitarian members by using the World Wide Web is a driving factor for these technologies.

a. ReliefWeb, Virtual OSOCC and HIC

ReliefWeb was launched in October 1996 and is administered by the UN OCHA. Recognizing how critical the availability of reliable and timely information in time of humanitarian emergencies is, the UN General Assembly endorsed the creation of ReliefWeb and encouraged humanitarian information exchange through ReliefWeb by all governments, relief agencies and non-governmental organizations in Resolution 51/194. The UN General Assembly also took note of the relevant decisions of operational agencies, organizations, programs and funds of the UN system concerning their participation in a coordinated response to humanitarian emergencies. [23]

ReliefWeb posts some 150 maps and documents daily from over 2,000 sources from the UN system, governments, NGOs, academia and the media. Map Centre also creates original ReliefWeb maps. All documents posted on the site are classified and archived in the ReliefWeb document database, allowing advanced searching of documents from past emergency responses. Redesigned site was launched in January

2005 and new features were added such as a filter tool for selecting content by relief sectors such as "water and sanitation" or by information source to find who is working in which sector in a given emergency. (Figure 7 shows ReliefWeb's home page) The database contains nearly 300,000 maps and documents dating back to 1981. In addition to Map Centre and the latest updates by country, region, or emergency, ReliefWeb offers various resource sections specifically targeted to relief professionals [28]:

- Appeals and Funding - Funding appeals for complex emergencies and natural disasters and financial tracking of responses to funding requirements.
- Policies and Issues - On-line library of reference materials covering humanitarian policies and issues of a global nature.
- Professional Resources - Information of practical use for relief professionals, including a sectored or thematic listing of "communities of practice," listings of job opportunities and training opportunities, and a contact directory of humanitarian organizations.

The Virtual OSOCC has been developed and is maintained by the Field Coordination Support Section (FCSS), established in 1996 within the Emergency Services Branch (ESB) of the UN OCHA in Geneva. Its mission is to use modern Internet technology in order to exchange disaster information continuously and simultaneously by relief actors from any place in the world. The enabling procedure for exchange is to store the information in a database on the Internet, thus facilitating access to topics of particular interest. Users can provide comments on existing information and, thereby, discuss issues of concern with other stakeholders. Based on the experience of usage of Virtual OSOCC, it provides an effective tool to facilitate the information exchange between responding governments and organizations throughout the relief operation. [25]

Figure 7 ReliefWeb's Home Page (April 2005).

The Virtual OSOCC was first published in July 2000. From then until 31 March 2005, 1732 discussions have been established to facilitate the exchange of information related to disaster response and response preparedness. Twenty-three hundred emergency managers from 483 governments and disaster relief organizations have accessed the information. The Virtual OSOCC was activated in 81 emergencies, including natural disasters and complex emergencies, in which 3478 comments were provided by 703 experts, from 167 countries and organizations. In addition, the Virtual OSOCC contains a contacts directory of 3759 persons from countries and organizations, 1502 of whom are currently registered as users and have access privileges to the information on the Virtual OSOCC. Because of security reasons, user accounts for Virtual OSOCC are only granted to emergency managers from governments and disaster relief organizations and are deactivated automatically after an inactivity period of six months [24].

The Humanitarian Information Centres have individual sites for each country and for unique relief operation, and each site follows a very similar format that is shown in Figure 8. Some of the functionalities that are supported by these sites are Coordination Tools, which include Contact Database, Meeting Schedule, and the Who's doing What Where (W3) Database; Map Centre, which consists of a wide range of Cartographic and Thematic maps, as well as Satellite Images relating to affected countries; and Info Centre, which includes operational data such as all assessments/surveys currently being carried out by various organizations working in the countries, categorized by date, district or sector.

Figure 8 HIC Web Site for Sri Lanka (May 2005)

b. ReliefWeb, Virtual OSOCC and HIC at 2004 Tsunami Relief Efforts

The individual initiative characteristic of OCHA led them to respond to the emergency immediately. On 26 December 2004, OCHA was in contact with the United Nations Resident Coordinators concerned. The United Nations Disaster Assessment and Coordination (UNDAC) Team was requested by the UN Resident Coordinator and dispatched by OCHA. OCHA was prepared to serve as a channel for cash contributions to be used for immediate relief assistance, in coordination with relevant organizations in the United Nations system. The situation report, which contains banking donors and immediate needs such as sanitation facilities, medical supplies, tents and helicopters for evacuation of people was available on ReliefWeb [26]. ReliefWeb started immediately as an information portal for tsunami relief efforts, as well as for other ongoing emergencies around the world. Information was presented in following categories: Latest Updates, Updates By Sector, Key Documents, Appeals & Funding, Maps, Who's Working, Country Profile, Travel Info, Vacancies, and Training.

Latest Updates provided a number of documents with various content types such as agreements, assessments, evaluations, field and situational reports, news, and analysis from various organizations such as academic, media, etc. However, the capability of filtering documents by date, sector, content type and organization was not properly worked out, which prevented the accessing of actionable information by humanitarian members and caused the required information to be buried in a haystack of other, irrelevant data. Update by Sector had documents related to agriculture, coordination & support services, education, food, health, infrastructure & rehabilitation, mine actions, protection/human, right/rule of law, refugees & IDPs, security, shelter & non-food items, and water & sanitation sectors. Various types of maps, organizations that had worked in disaster relief and country profiles from different sources such as the CIA or countries' governments were provided. There were almost no documents dealing with training and vacancies when the relief organization searched for professionals to hire for limited periods.

The Virtual OSOCC may be the most effective tool used in the initial phase of the tsunami relief efforts. The organizations requested crucial information in order to start their efforts. For example, the Disaster Relief Network (DRN) set up operation at the airport in Colombo and signed an agreement with the Government of Sri Lanka to receive all incoming relief commodities. Agencies/organizations who were sending relief commodities to Sri Lanka were requested to provide the following information on the Virtual OSOCC, in addition to the clearance request to the Ministry of Foreign Affairs [27]:

- Cargo specification
- Weight and quantity
- Origin
- Consignee (or unsolicited)
- A contact point of the receiving agency in Sri Lanka and instructions on how to contact
- Specification if commodities were for common use or for specific agency

Even though this service was provided for only pure relief commodities, by using Virtual OSOCC, this service established coordination where immediate response was critical, especially where people desperately sought help under horrible conditions.

As expected, military entities also used civilian technologies. It was mentioned that RFA was one of the functionalities of APAN CMOC that was used by US PACOM. The RFA forms for movement of cargo, people, and other required assistance, and their instructions, were posted on Virtual OSOCC under the civil-military discussion group [21]. The information was also disseminated as widely as possible through NGOs and other networks.

The HIC web site for Sri Lanka established place codes (P-Codes), similar to zip codes and postal codes, which were part of a data management system providing unique reference codes to thousands of locations. The contact information from organizations, where and in which sectors organizations worked, and meeting information were gathered and published on the Internet. Contact information collected via web pages and input to a database enabled users to search organizations by type and location, at the district level. Where and in which sectors each organization worked and meeting information were required to be submitted by the organization via email to the HIC. That information was organized and published in PDF format. The Map Centre functionality of the HIC provided map catalogues related to various sectors such as education, health, and IDPs. The first map was available on 15 January 2005, and the rest were added at a rate of approximately one per week. By the beginning of April 2005, there were 18 maps available at the site [29].

c. Discussion

ReliefWeb has seen steady growth in usage. In 2002, ReliefWeb received 1.5 million hits per week, while by 2004 the site received approximately 1 million hits a day. Shortly after the South Asia tsunami disaster of December 2004, it received 3 million hits a day on average [28]. In terms of gathering information and disseminating it through the web, ReliefWeb provided level 1 and 2 of collaboration. The individual organizations with common interests (reducing the suffering of tsunami victims and providing recovery after disaster) operated to exchange information. Involvement of local communities and governments in ReliefWeb was very limited for several reasons, including lack of access the Internet and a crush of other responsibilities. ReliefWeb supported worldwide recognition of the disaster and encouraged many agencies to participate in the relief efforts. On the other hand, the lessons learned from the disaster relief efforts indicate that the size of the agencies and aid provided by them is not important. Integrated effort with local communities and host country assets was the key factor. The survivors needed appropriate aid, not just any aid; some of the aid provided was not appropriate (clothes, for example). ReliefWeb did not have the functionality to provide required coordination in order to prevent those kinds of mistakes.

Table 4 shows the statistics about Virtual OSOCC. The number of discussions established in Virtual OSOCC from February 2005 to March 2005 was about 44, which also included the discussions related to emergencies other than the 2004 tsunami Disaster. The number of comments provided by the experts was about 210. When the approximately 700 experts over 160countries and the coverage of the emergencies are taken into consideration, this indicates that Virtual OSOCC provided limited discussion and comments related to the relief coordination. Even though there was limited interaction among participants of Virtual OSOCC, discussions and comments provided by Virtual OSOCC created a collaboration environment with participants working as a team to achieve a common goal. That level of collaboration is level 3, as mentioned in chapter II.

Duration	**Discussions**	**Comments**
July 2000 - February 2005	1688	3268
July 2000 - March 2005	1732	3478

Table 4. Virtual OSOCC

Establishing the HIC was very quick, during the first week after disaster; however, success of the HIC depended on various information and data analyses that required data provided from the field. The method of collecting information required Internet connection and caused limited contribution from the local communities. For example, there were only six assessment forms from five international organizations, and “Needs of Tsunami Affected Schools in Southern Province” was one of them. The basic information needed for that form was the number of enrolled student before and after tsunami; assistance received such as number of textbooks, schoolbags, and furniture; and additional required numbers for those items [29]. Such information required gathering data from the local community and governments.

C. SUMMARY

Situational reports and information about the areas in which both military and civilian relief members worked were provided by VIC, APAN CMOC and ReliefWeb. Such information not only increased the situational awareness of humanitarian members, but also influenced decision makers about operations. For example, separatist rebels and troops in Banda Aceh (Indonesia) have been fighting for nearly three decades. Before the disaster, the area was a zone of military operations and was off-limits to foreigners. Both sides agreed to an informal truce in the aftermath of the tsunami to allow distribution of aid and to reassure the thousands of international relief workers there; however, Indonesia's military chief claimed on 20 January 2005 that the 120 suspected rebels killed by his troops since they were attempting to disrupt the relief effort. Those events raised questions at the UN about international military personnel providing security to humanitarian members and relief efforts. The countries affected had considerably different social, economic and political considerations that affected ongoing relief efforts.

Economic considerations of organizations participating in relief operations also influence the effectiveness of efforts. Due to funding decisions, APAN closed many of its information sites in February 2005, and stopped providing some resources that served USPACOM and humanitarian members' information requirements; however, APAN continued the APAN CMOC features at its networks.

Lessons learned from previous natural disasters noted that when planning programs, organizations often rely on external criteria (generally economic and scientific) in order to differentiate between various functional groups within a community. External criteria used in relief efforts can be at odds with local customs and culture. If they are not contextualized properly, interventions based on such criteria can have a disruptive effect. Community participation is viewed as key to ensuring the durability of relief operations and reconstruction interventions.[30]

Technologies used in the Indian Ocean tsunami efforts--ReliefWeb, Virtual OSOCC, and APAN CMOC--served effectively during the initial phase of the operation. They served to focus individual efforts where they were needed most and helped validate, coordinate and prioritize RFAs from the international humanitarian community and affected countries. To find a local solution, or the closest units that could solve local needs identified by different entities, was the concern of the RFA process. The validation of the requests needed to have information about the region and the working humanitarian groups within that region, and the type of support that each humanitarian group could provide.

One of the issues that affects or impacts the interface among the military, International Organizations and Non-Government Organizations and affected countries during relief efforts is the lack of participation of the community. The lessons from natural disasters, especially floods and earthquakes, show that “the main response will come from governments and the people themselves.” The sustainability of disaster recovery will depend on forming the basis for recovery by existing local development planning, and revising reconstruction activities in terms of self-identified community needs.[30] Therefore, the Information Technology planned for use in relief operations should allow those communities to organize their own committees to document their situations, needs, and skills. Experience has shown that high-transfer-rate networks are likely to be established only among district centers and a few camps. This was one of the limitations that caused a lack of access to actionable information and, most importantly, failure of data collection from the end users--volunteers, refugees, and humanitarian members--via the World Wide Web.

IV. LOCAL IT COMMUNITY AND FIELD LEVEL PROBLEMS

A. INTRODUCTION

The efficiency of the technologies mentioned in previous chapters depends on accurate information from the disaster area. Effort spent in validating requests could be reduced by an effective information-management strategy at the field level. The databases that support this information-management system should contain the IDPs, camps, districts, relief items, logistics, policies, procedures, contact information, organizations or participants and their expertise such as telecommunications, transportation, education, and water supply.

Figure 9 shows the dimensions of the problem boundaries, the decision makers and the problem solvers. It is thought that the expectation for an Information Management System for disaster relief operations is to provide actionable information, from relevant sectors, for the different levels of decision makers, and to allow them to find solutions that use host-nation resources as much as they can. Reducing the need for assistance from the NGO, IO or foreign governments and military organizations is a key factor for disaster recovery, both individually and as a country.

Figure 9 also helps to understand the degree of data gathering necessary for an Information Management System. Either to identify the problem boundary in the lowest level or to find a solution within its boundary, it is required that data about disaster victims, host nation volunteers, local communities and so on be gathered as completely as possible. During the 2004 Indian Ocean tsunami relief operations, host nations collected and disseminated such information with help of local IT communities.

This chapter will focus on local IT communities in relief efforts and field level problems. This will enhance understanding of the requirements for Information Systems in relief operations, at the field level. Among the many IT solutions from host-nation IT communities, the Sri Lankan IT community’s solutions for avoiding duplication of requests and improving resource coordination during the 2004 Indian Ocean tsunami relief operations will be examined.

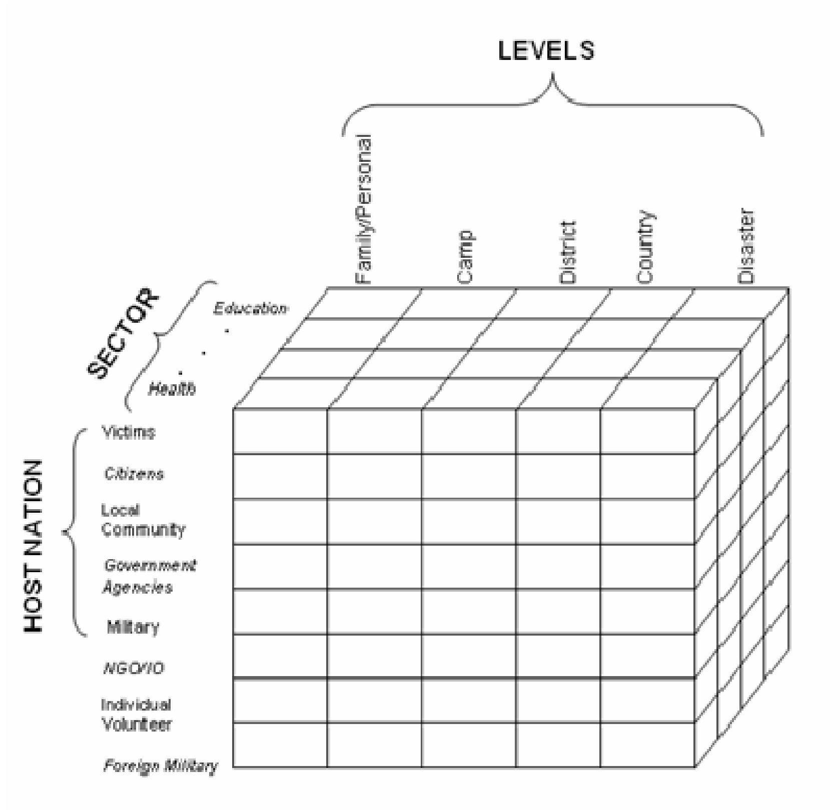

Figure 9 Dimension of Information at a Disaster Relief Operation

B. SAHANA

It is a fact that there are few countries or organizations today that can afford to invest their resources in disaster management when there is no disaster present. This is not only true for poor, developing nations, but also for richer and developed countries. Even though APAN served during tsunami relief efforts, many of its functionalities were canceled due to lack of funds [18]. There are always higher priority items that need funding. As mentioned in Chapter II, this is more likely for military organizations where relief operations are not the main priority. One of the countries hit by the 2004 tsunami was Sri Lanka. When the tsunami hit the coast of Sri Lanka, there was no information management system that could provide a simple IT solution for disaster management.

Approximately six months after the event, and based on the reports collected by government and international organizations, the devastating impact of the disaster on Sri Lanka was summarized as [31]:

- 31,299 people dead
- 4,100 people missing
- 516,150 people currently registered as displaced
- 275,000 lost jobs
- 86 medical facilities and 195 educational facilities damaged or destroyed
- 31,000 transitional shelters completed and 54,266 currently scheduled, housing more than 250,000 people; 9,480 families still living in tents as of 8 June.
- Over 100,000 people currently being provided with drinking water

Those are only a few of the facts that indicated the need for massive efforts during and after the tsunami disaster. This fact was realized by the Sri Lankan government, and thus the Center for National Operations (CNO) was established on 29 December 2004 to set up such an operation, to coordinate the rescue and relief operations in a cohesive an efficient manner.

1. ICTA Initiates Sahana

The mandate of the CNO was to monitor and coordinate all initiatives by government ministries, agencies and other organizations [32]. One of the agencies was Information and Communication Technology for Sri Lanka (ICTA), and one of its initiatives was Sahana. The purpose was to connect those who wanted to assist with those in need, prevent the duplication of tasks, maximize the utilization of resources and ensure that all efforts fit into the overall objectives of Sri Lanka's government.

A group of Sri Lankan volunteers decided to help coordinate the relief efforts; therefore, they involved the Sahana Project. Over 40 people contributed to its development, from various groups and organization as well as from various nations. They quickly built the Sahana System over a two-to-three-week period as a collection of integrated applications to handle an increasing amount of functionalities. After it was authorized, deployment of the Sahana System was executed by both CNO and ICTA. The

Sahana System was modified, and new functionalities added, while it was in use by relief members.

2. Components of Sahana

Sahana has independently usable subsystems that interact with each other via a set of shared databases. The following table lists the components of the Sahana System[33]:

Component	Description
Organization Registry	Keeps track of all organizations and the ownership areas they have in the relief efforts
Request Management System	Database of all requests for support from various locations such as camps and hospitals, as well as offers of support from relief providers
Camp Registry	Registers all temporary camps, hospitals and locations set up to house the victims of disaster
People Registry	Database of missing, displaced, dead, and orphaned people, including pictures, finger prints and DNA samples, with advanced search capabilities
Assistance Management System	Database of all pledges of assistance and attempts to match them to the requests. Also records where the assistance was provided

Table 5. Sahana System Components

3. Problems in the Beginning

After the disaster, many organizations recommended IT solutions for the relief efforts. Government regulations and privacy issues (i.e., DNA samples) were two of the concerns during the development phase. One of the expectations from the Sahana System was to provide value to the NGOs. There were many applications available at the time that could be used to develop an information management system, but the politics were not so clear. Therefore, developers made close contact with both CNO and the UN, and tried to convince them that the Sahana System could provide actionable information to the relief operation. Their relationship with the NGOs provided good requirement gathering, which also helped them to convince governments to use the Sahana System as the backbone of the information system--it also served as the CNO data center.

In addition to the technical side of the development process, they also had political problems related to the funding issue. Some organizations donated hardware to the development team for use in Sahana project (i.e., notebook computers). When asked, the local Microsoft agency had refused to give free XP licenses for those notebooks, and so the development team got them with PC-DOS only. Because of the lack of commercial motivation to build software for humanitarian disasters, and license restrictions, developers chose the open-source approach. Sahana was written in PHP and Java and runs on Linux, using the Apache Web server and MySQL as the database.

Data gathering for the Sahana System started slowly, especially for the people database. By the end of January, volunteer students from the Sri Lanka Institute of Information Technology (SLIIT) and University of Moratuwa had entered around 6600 families' raw data received from the field. Various agencies, government secretaries and organizations tried to collect data from the tsunami victims during the relief efforts, which caused frustration among the affected people. They no longer wanted to provide collaboration because their requests were not provided. A group of people who worked in the government organization called the Humanitarian Disaster Management Center speeded up the data-gathering process for Sahana. The group crossed the country to get the actual data from the various divisional secretaries and brought them to Colombo, the center of the relief operation in Sri Lanka. As of 11 February 2005, there were 30,619 families in the system, which probably represented more than 125,000 people--approximately one fifth of all those affected in the country.

4. Why Did Sahana Stop?

As of the 11 February 2005, the CNO, the organization that ran the immediate relief coordination in Sri Lanka, ceased operations, and with that the government signaled that the main focus had changed to the recovery and reconstruction phases. That was the task of the Task Force for Rebuilding the Nation (TAFREN). Sahana was used by the Sri Lankan government for a while longer but, by the end of May, it could no longer support the needs and was stopped. The development team submitted a proposal for funding to make Sahana truly reusable and global, and engaged TAFREN to obtain the IT needs for their task [36]. Sahana was ongoing project at the time of this thesis research.

During the development phase of the Sahana Project, some volunteers also participated in the project from foreign counties. They used e-mail to discuss the issues. The local development team met as required and tried to catch-up on the relief requirements. Although a lot of volunteer effort was well intentioned in building a system at the point of disaster, they had to struggle to create some components of the Sahana System. The system was built so quickly that its reliability and extensibility were often compromised for the sake of meeting the deadline. This meant that not all components of the Sahana were as effective as others, as some came in too late to be utilized or data had already been captured in other forms from other secretaries as mentioned above [33]. Another reason for failure was the lack of experience of the development team in the disaster management domain, not a lack of technical knowledge. There were no mobile stations to capture data from the field, and no IT strategy to use the high-speed Internet connectivity available at district-level coordination centers.

C. UNIVERSAL DISASTER INFORMATION MANAGEMENT SYSTEM PROBLEMS

Regarding to Sahana Disaster Information Management System and lessons learned from other disaster information systems used in relief efforts, problems are identified for Disaster Information Management System which can be used universally. The processing of missing people in the Sahana System raised an issue that is important for any Disaster Information Management System--information should be secured in order to reduce the possibility of data privacy violation or abuse for nefarious reasons [33]. English was used for the interface of Sahana, which increased the possibility for participation by international organizations. It also influenced governments to use Sahana; in other words, the UN and NGO’s commitment to system development attracted governments to the project. However, it is thought that participation by the local communities was prevented because of this. In addition to security and language concerns of Sahana System, connectivity problems, mobility of system and cost of sharing information will be inspected in further details.

1. Cost of Sharing

Relief operations in undeveloped, developed, developing countries vary according to who assumes the role of managing the operations. Developed countries mostly have their own disaster management systems. On the other hand, undeveloped countries depend mostly on UN efforts--for example, some countries in Africa where local community participation is very limited--for IT technology used in relief operations. For developing countries, there is a need for inexpensive hardware and software to developing Disaster Information Management System. The United Nations Education, Scientific and Cultural Organization (UNESCO) has recently developed a partnership with the Free Software Foundation (FSF), established in 1985, which is dedicated to promoting computer users' rights to use, study, copy, modify, and redistribute computer programs. The product of this partnership is the Free Software Directory, which was started in September 1999 to catalog all useful free software that runs under free operating systems [37].

Sahana was developed with open-source approaches to greatly reduce the development cost of software. Therefore, it is possible to run it on inexpensive hardware. It also eliminates the need for dedicated hardware. It was designed to be deployed on any PC equipped with Linux LiveCD, which enables the entire system to be booted up and brought online [33].

2. Security

Another area that the developers of Sahana had to look into was ensuring data privacy to address problems with data abuse such as identity and property theft during disaster situations. Sahana provided advanced picture research to find missing persons from IDP camps and to identify death victims. A great deal of human trafficking, especially in children, was reported after the tsunami disaster. Picture research provided the capability of finding victims of human trafficking; however, it was not used in local security departments. The sensitivity of such information required that only a limited number of personnel be allowed access to certain restricted processes in the system. Though this was as much an application layer problem, developers could not assume that the database access was entirely secure in relief operation scenarios. So, they discussed that the security would have to be passed to the data itself, probably by using public/private key encryption. It was not implemented in the Sahana System.

3. Connectivity and Mobility

In anticipation of limited connectivity options, the developers of the Sahana System traveled with a modem-, WiFi-, BlueTooth- and LAN-enabled laptop, a WiFi- and GSM-enabled Blackberry hand-held (which is world-band and operates on 900/1800 MHz GSM/GPRS wireless networks, allowing for international roaming between North America, Europe and Asia-Pacific [34]), a GSM mobile telephone, and a Digital mobile telephone. Only the GSM mobile provided limited connectivity in impacted areas (the Blackberry also had limited connectivity; however, it failed on day two of their travels due to excessive humidity short-circuiting the device).

4. Cultural Impediments

During the development phase of the Sahana System, countries affected by tsunamis were examined. It was observed that cultural barriers have played an important role in creating information sharing environments and deployments of systems. For example, the Thais are a proud people, and they did not in general perceive a need for outside assistance beyond that provided by necessity for foreign nationals following the tsunami. Not all Thais welcomed the adoption of western emergency management doctrines. They believed that their own social and government structures provided adequate coverage options. The predominant religion of Thailand is Buddhism, and many Thais hold to faith to prevent future disasters. During the Sahana developers' inquiries, it was seen that ignoring the cultural impediments had potential risk to deployment of the system in affected regions or countries. This also emphasized the importance of local IT community participation in the Sahana project.

5. Language

In closing, the biggest concern remained that of target users being able to access the Sahana system at all. In addition to poor rural Internet connectivity, target users' Internet literacy was generally low, and acceptance of English as a written language had yet to extend beyond a few affluent regional centers. The desire of many local people from the IT community to formulate internal solutions influenced the usage of the Sahana System, which was primarily designed in English. Studies have shown that victims of disaster get very impatient and angry at having to fill out a form for each different agency involved. Since it is easier, they prefer a system that supports their own language. This was one of the reasons that increased the gap between local communities and international organizations in the 2004 tsunami relief efforts. In fact, that was one of the gaps that Sahana was designed to fill. Sahana was meant to be a system that both local agencies and NGOs could use, because the data could be reused, and different agencies did not have to go out and recollect the same data that others had already collected; rather, they could just go out and fill in the gaps. Even one month after the disaster, there was no structure and system in place on the ground. Various agencies, government secretaries and organizations tried to collect data from the tsunami victims during the relief efforts. A group of people who worked in the government organization speeded up the data-gathering process for Sahana, and volunteers from universities helped overcome the language barrier by translating and entering data into the Sahana system. Unfortunately, collected data was not useful because data had already been captured and used in other forms from other secretaries.

D. SUMMARY

It is seen that most of the processes that address problems in various sectors call for the creation of a database to provide actionable information to the relief members. Unfortunately, neither UN nor affected countries successfully designed and implemented a system which used a database to help processes in various sectors. There was no standard framework to use it in Disaster Information Management System. One goal related to the standard framework is to help the humanitarian community improve the management of information by making better use of basic building blocks. It is seen that the capability of vertical and lateral information exchange is needed. Failure of that exchange results in more involvement of non-host organizations in the relief operations, which makes the recovery phase more difficult. The contribution of the local IT community or host-nation IT community, such as IT students and faculty members from universities and IT-related companies, is crucial. Their knowledge and awareness of the capabilities in the field will enable them to find appropriate ways to collect data and to provide information, requested from different levels, in various formats. There is a need to have a universal Disaster Information Management System that the humanitarian community uses and one that is easily adaptable by help of host nation IT community.

Before answering “Who should develop such Disaster Information Management System?” There are some critical questions need to be answered first:

Who owns the data?

Who defines the roles of the various organizations and volunteers?

Who assigns access controls for each user and group?

These questions lead us to another question: who owns the Disaster Information Management System? Unfortunately, the answer to that question is not easy. There are some factors affecting ownership of the system.

First of all, the system has confidential information about people affected by the disaster. Governments tend to keep secret information about their own citizens and the systems that enable them to carry out their responsibilities. Even though NGOs such as the UN are well-intentioned, ownership of such data by “outsiders” might not be welcomed by the governments of affected countries. It can only be accepted in the case of undeveloped countries, since the maturity of undeveloped counties are not capable of managing the tasks required for a Disaster Information Management System.

Second, the commitment of people or organizations is another factor. NGOs, especially the UN, participate in many humanitarian operations around the world. Being unaccountable to governments and profit-making companies enables them to serve in relief operations without regard to nationality, ideological belief, religion or sex. That makes them good a candidate in terms of organizational commitment. But, there are many emergencies that require UN participation, and even the UN does not have enough resources for all emergencies. After the Indian Ocean tsunami disaster, the South Africa humanitarian crisis is one example where the UN has participated in ongoing emergencies. From the affected countries’ point of view, people who lost their relatives and friends are self-motivated to solve problems in the relief domain, especially for their citizens. Responsibility of government requires commitment. It is seen from the development process of the Sahana System that people who work IT-related jobs are willing to get involved. They may spend most of their time developing or to managing the Disaster Information Management System.

A third factor is politics. It is seen that different organizations bring different IT to relief environments. Volunteers and non-profit organizations offer different IT solutions. Even though some of them are free solutions, implementing proposed systems requires assistance from the political sphere. It is not a technical problem that can be solved by IT people. NGOs should find a proposed system valuable for their missions. The government or agencies responsible for relief operations in affected countries should be convinced about the benefits of the proposed system.

Following chapter will identify the requirements of Disaster Information Management System which addresses the above issues as well as the lack of commercial motivation to build software for humanitarian disasters and the cost of system design and implementation. There are architectures, approaches and concepts that enable the outcome of design be universal. Those will be discussed for designing the Disaster Information Management System by examples.

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V. DISASTER INFORMATION MANAGEMENT SYSTEM REQUIREMENTS

A. INTRODUCTION

In order to addresses the problems in disaster relief domain by designing Disaster Information Management System which can be used by various organizations from different countries, the scope of the system is identified in this chapter. Examples are given for critical sectors within scope. Following architectures and concepts are considered for designing Disaster Information System: Distributed Database, Client/Server Architecture, Geographic Information System (GIS), Localization and Internationalization. Using Open Source methodology which reduces the cost and increases the participation of many researchers and individuals from IT community will be discussed to build software for humanitarian disasters.

B. SCOPE

To identify the boundaries and scope of the Disaster Information Management Systems that will be used in relief operation is the most important factor in system design. It is thought that parameters should be:

- The system is only to be used in relief, recovery, and rehabilitation efforts.
- The system is not supposed to be extended to a government data center.
- Requirements must be obtained from NGOs and governments for critical sectors such as health.
- Local IT community participation should be encouraged.
- The technologies used in the system should be available to everyone.

Within this scope and these boundaries, The Disaster Information Management System should add value to the missions and goals of the relief efforts. Sources from many sectors in relief efforts agree that “needs assessment” must be ongoing and that success of the relief operation is dependent upon robust needs assessment. Where ongoing assessment is missing, relief can continue for too long and, as a consequence, transition between relief and recovery can be uneven and problematic.

A number of key factors upon which the most accurate and useful assessment are dependent are timeliness, composition of assessment teams (multi-disciplinary), data collection techniques, good relationships with local institutions, and prior knowledge of local communities [30]. It is worth mentioning that there are various levels, such as the district level. Each level has a needs assessment that requires queries, which are performed locally. Most updates for the data are also performed locally. Defining a data set that enables assessment should be accomplished with input collected from each relief sector. Each affected country has unique organizational units and regulations for these sectors; therefore, it is not possible to create one assessment that fits all countries. Effective ways of collecting the data set could be identified by conferences before any disaster that requires a relief operation. This would increase the prior knowledge of local communities and create good assessment teams. The internationalization that will be covered later in this chapter will enable NGOs from other countries to engage in relief efforts more effectively. The most critical sectors are defined as:

- Water and Sanitation
- Health
- Shelter and Housing
- Education
- Livelihood
- Refugee and IDPs
- Women and Children
- Protection

Within the scope of the Disaster Information System, requirements for each sector vary. Success of relief, recovery, and rehabilitation efforts are dependent upon appropriate transition through those phases. Most of the considerations for relief efforts in those sectors are temporary solutions and address the devastating impact of disaster.

The shelter and housing sectors deal with problems such as tents, transitional housing, and power generators for IDP camps. The water and sanitation sectors deal with the problems of distribution of potable water provided by government and private agencies and the problems of using water for bathing or washing and open land or forest for toilets, thereby contributing to the risk of spreading disease. The health sector concern in the relief phase is to create mobile hospitals or medical centers, to use local hospitals for medical health care and to provide additional staff as doctors and nurses. NGOs such as the World Health Organization (WHO), under the UN system, work on aspects of water, sanitation and hygiene where the health burden is high. Requirements obtained from the WHO for the health, water and sanitation sectors are valuable for the Disaster Information System, especially in the relief phase. Starting education as soon as possible helps the recovery phase of a disaster. Regarding the scope of relief operations, establishing temporary schools and identifying and providing for schools'--including existing schools affected by disaster--needs such as furniture, schoolbags and temporary managers or teachers are problems that relief operations should deal with. Establishing a self-reliance community in the affected area and restoring the livelihoods of displaced population are more related to recovery and rehabilitation, and may require approaches and methodologies for social-economic empowerment through an employment-oriented strategy. It was a given that 275,000 people lost their jobs in Sri Lanka alone. During the relief operation, there arose opportunities to use people from the affected areas; therefore, the main objective of relief operations, which is to help people to help themselves, could be established. It is better to hire temporary employees from host nations instead of bringing them in from outside. When creating a database, one of the requirements is to obtain job-related data for the people database. Using volunteers appropriately is also another concern. In order to match their skills to specific jobs, it is necessary to identify jobs and obtain data about volunteers' skills and expertise. Women and children are more vulnerable to disasters; it is more likely to see a higher exposure of women and children to malnutrition and famine, sexual violence, and displacement. The women's risk of unemployment and loss of income-generating work after disaster is higher due to restricted access to nontraditional jobs and credit. The age-specific needs of young people, including child-care in disaster relief, are among the concerns that are mentioned by experts. The Disaster Information Management System may provide gender- and age-specific information for the affected area, by using simple queries that could be valuable for relief operations. Another issue with children is that, after a disaster, many missing children are not capable of finding their parents or relatives. Therefore, parents and relatives who try to find missing children should be assisted by the Information Management System. Pictures of missing people are commonly used by parents and relatives, necessitating a search capability indexed by picture; this has been established by the Sahana System and today's technology provides a free solution for this feature. Security-and-protection-sector-related problems are large in scope. They include not only security of displaced people and protection of children from abuse, but also security of relief aids and protection of critical public and private properties. Reports of rebels stealing aid and even kidnapping aid workers have been noticed in various relief operations around the world, including in the Indian Ocean tsunami relief efforts.

C. DISTRIBUTED DATABASES

From the experience of Sahana, the dynamic extensibility of the database during a disaster situation is the biggest concern. Because of limited or intermittent connectivity in impacted area, there is a definite need for any design to take into account three scenarios: high-bandwidth connectivity, low-bandwidth connectivity and offline. Since the central database approach depends on one computer available at all times, everybody would suffer in the offline scenario. Another drawback is the cost of using a highly capable database server to handle the transfer of data to a central database. Since most updates and queries are performed locally, using a central database system will degrade the performance of the Disaster Information Management System.

Increasing the performance of the Disaster Information Management System and reducing the risk of pure implementation could be accomplished by using distributed-database architecture. A distributed database system consists of multiple independent databases operating on two or more computer that are connected and share data over a network. With the distributed database approach, expanding into new affected areas would be accomplished by adding additional computers with database capabilities to support relief operations in the new area. Since data is separated into different computers, the overall system might perform well even with computers with low processing capacity. It is easier and cheaper to match the changing needs of the system. It was found that developers should always consider using inexpensive hardware and software in their IT solution. Even though many companies might provide some hardware during relief operations, developing a Disaster Information System that can be operated by inexpensive hardware and software is critical in order to decrease risk in the implementation of system.

On the other hand, it is difficult to create a system that handles distributed databases. In addition to the complexity of concurrency and deadlock, the following problems have been identified in the distributed database approach for a Disaster Information Management System:

- Defining an effective master logical schema for a disaster management domain
- Handling and synchronizing between distributed data repositories
- Access and data transfer protocols

During research, it was found that off-line operation with data import/exchange via media such as CDs was crucial for success. This approach was used in the Sahana system to collect data from rural area that had no connectivity for long periods during the 2004 Indian Ocean tsunami relief operations.

Since research indicated that only the GSM mobile provided limited connectivity in impacted areas, it is beneficial to use mobile phone as part of IT solution. Figure 10 shows the prototype of the Sahana home page on a mobile phone, as suggested by Tom Worthington (one of the current developers) on 6 April 2005. It was too late to implement this feature in the current Sahana system at that time.

Figure 10 Sahana Home Page on a mobile phone browser

It was also suggested that web interface of disaster management software should be redesigned to make it more effective in an emergency. Two CSS (Cascading Style Sheets) were created and tested: one for handheld small-screen devices to turn off unnecessary images and lessen margins, and another for the Sahana home page used by CNO. Assuming a 5-kilobyte-per-second modem was used, downloading time was reduced from 10 seconds for the Sahana CNO page to 3 seconds for the proposed Sahana main page and one second for the mobile phone browser.

File	**Existing Size of Sahana CNO Page**	**New Size of Proposed Sahana Page**	**Proposed Mobile Option**
HTML	5.63	1.99	1.99
Default CSS	3.20	2.38	2.38
Images	40.49	11.88	1.35
Total	49.32	16.25	5.72
Reduction		**% 67**	**% 88**

Table 6. Efficiency Comparison of Used and Proposed Interfaces (After Ref [35])

D. CLIENT/SERVER ARCHITECTURE

The client/server software architecture is a versatile, message-based and modular infrastructure that is intended to improve usability, flexibility, interoperability, and scalability. A client is defined as a requester of services, while a server is defined as the provider of services. The two-tier and three-tier architectures are example of server/client architectures. In the two-tier client/server architecture, the user system interface is located in the user's desktop environment and the database management services are usually in a server, which is a more powerful machine that services many clients. A limitation of the two-tier architecture is that implementation of processing management services using vendor-dependent procedures restricts flexibility and choice of Database Management System (DBMS) for applications. With the three-tier client/server architecture, the third tier provides database management functionality and is dedicated to data and file services that can be optimized without using any proprietary database management system languages. The three-tier architecture is used when an effective distributed client/server design is needed that provides (when compared to the two-tier) increased performance, flexibility, maintainability, reusability, and scalability, while hiding the complexity of distributed processing from the user [38]. Those qualities are critical for successful implementation of a Disaster Information Management System.

Within three-tier architecture, a flexibility quality could be provided by using mobile clients that allow access to the Disaster Information Management System, through mobile devices in the field, and a remote station that allows for disconnected operation using localized databases. Using client/server architecture also allows for the implementation of a Geographical Information System (GIS) in any disaster management system, which will be mentioned later in this chapter.

E. INTERNATIONALIZATION AND LOCALIZATION

In order to create a system that can be used universally, it is necessary to mention two processes:

1. Internationalization: This is the process where the code is modified so as to be culturally independent.

2. Localization: This is the process where the software is customized for each language supported.

Internationalization (abbreviated I18N) describes the process of designing and developing programs and software products so they can be adapted to various languages and regions to function in multiple locales [6]. I18N is the process where code is modified in such a way that it is completely independent of any cultural-specific information The I18N process involves identifying the locale in which the application will be utilized, designing the appropriate features, and writing the code that will function well in the supported locale. Localization (abbreviated L10n) requires modifying a software product to fit the requirements of a particular locale and may include customizing features and translating user interfaces, documentation, packaging, and dialog box geometrics [6]. Localization makes software linguistically and culturally appropriate to a given target locale (country/region and language) where it will be used [39]. Locale is defined as a set of conventions such as written language and formats for dates, numbers and currency within a particular geo-political region. That enables developers to discover required changes and make them retroactively to applications that were written in one language. It also helps the development of parallel versions, avoiding a lengthy, expensive product cycle and eliminating the need for redesign. Since the Disaster Information Management System will be used globally, it should contain software that supports many languages. Menus, dialog boxes, and messages that aid the user interface will be written in source code. Translating source files are difficult, time-consuming and expensive because the combination of linguistic and engineering skill sets are uncommon, mistakes are made easily, and occasionally, the resulting translated code does not function as expected [6]. Using the Open Source approach might help to gather experts from many countries and reduce the risk of inappropriate localization processes. That would also help the testing process of the system, which enable testers to ensure that the system works at least as well as the original--most probably written in English code.

F. OPEN SOURCE

The Open Source approach would be the appropriate approach to design a Disaster Information Management System. Several reasons were mentioned previously. In summary:

- There is the lack of commercial motivation to build software for humanitarian disasters.
- There are license restrictions for some products, even for certain regions.
- There are an increasing number of non-software companies developing software.
- The Internet is the platform through which Open Source is developed, increasing the gathering of experts from various fields.
- It is encouraged by the UN, which is the main player in humanitarian assistance.
- It helps Localization. Users do not need to convince a vendor to support their language; they can simply add that capability themselves.
- It is free.

As of August 2005, there are 104,946 registered projects and 1,124,650 registered users at sourceforge.org, which is the world's largest development and download repository of Open Source code and applications. Below is some of the open source software listed under The Free Software Directory, supported by UNESCO and FSF [37]:

Apache - Web server: Apache is a powerful, flexible, web server. It is highly configurable and customizable, provides full source code and comes with an unrestrictive license, runs on a variety of operating systems, is actively being developed, encourages user feedback, and implements frequently requested features including virtual hosts, unlimited flexible URL rewriting and aliasing, customized responses to errors and problems, content negotiation, and multiple DirectoryIndex directives.

MySQL - Relational database management system: MySQL is a fast, reliable, and easy-to-use relational database management system that supports the standardized Structured Query Language.

mysql_client - MySQL client interface that supports multiple operating systems and languages: 'mysql_client' is a MySQL database GUI client program. The purpose of MySQL Perl/CGI Client is to provide a useful and flexible client interface for MySQL database servers. It can support multiple operating systems and languages.

My SQL Navigator - MySQL database server GUI client program: MySQL Navigator is MySQL database server GUI client program. The purpose of MySQL Navigator is to provide a useful client interface to MySQL database servers, while supporting multiple operating systems and languages. You can currently enter queries, get result sets, edit scripts, run scripts, add, alter, and delete users, and retrieve client and server information.

PostgreSQL - A robust SQL Object-Relational Database: PostgreSQL is a sophisticated Object-Relational DBMS, supporting almost all SQL constructs, including subselects, transactions, and user-defined types and functions.

PostGIS - Adds support for geographic objects to PostgreSQL: PostGIS adds support for geographic objects to the PostgreSQL object-relational database. It "spatially enables" the PostgreSQL server so it can be used as a backend spatial database for geographic information systems (GIS).

Yate - Telephony engine: "YATE" (Yet Another Telephony Engine) is a telephony project that is written in C++ and that will support scripting in various programming languages.

phpcollab - Groupware project: It is groupware module that manages web projects with team collaboration, users management, tasks and projects tracking, files approval tracking, project sites clients access, and customer relationship management (Php / Mysql, PostgreSQL or Sql Server).

G. GEOGRAPHIC INFORMATION SYSTEM (GIS)

Geographic Information System (GIS) is an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. It can also be defined as a computer system designed to allow users to collect, manage, and analyze large volumes of spatially referenced and associated attribute data. The GIS database contains both map data (depicting the locations of geographical objects) and attribute data (describing the physical characteristics of each object). During a GIS analysis, site (map) data is linked with situation (attribute) data. It is this link, automatically performed by the GIS software, which gives GIS its analytical power [40].

During a disaster, effective response and relief operations include incident mapping; establishing priorities; developing action plans; and implementing the plan to protect lives, property, and the environment. GIS allows high-level decision makers to quickly access and visually display critical information by location. This information can be easily shared with NGOs and military organizations for the coordination and implementation of relief efforts.

The power of a GIS comes from the ability to relate different pieces of information in a spatial context and to reach a conclusion about this relationship [41]. There exists the potential to use this power in the disaster management domain. For example, the HIC web site for Sri Lanka established place codes (P-Codes), similar to zip codes and postal codes, which were part of a data management system providing unique reference codes to thousands of locations. The Request Management System component of the Sahana System contained a database of all requests for support from various locations such as camps and hospitals, as well as offers of support from relief providers. Most of the information in a Disaster Information Management System contains a location reference, placing that information at some point on the globe.

Figure 11 shows the information flow in a Disaster Information Management System that uses GIS inside its client/server architecture. Upon a request from a client, the web server specifies necessary information, including what geographical data and what part of the area are needed. Then, the GIS server abstracts accumulated geographical data within itself, or refers back to the database server if necessary, and then processes it to the web server. The web server sends information in a user-friendly format. The client then accesses the data through a web browser.

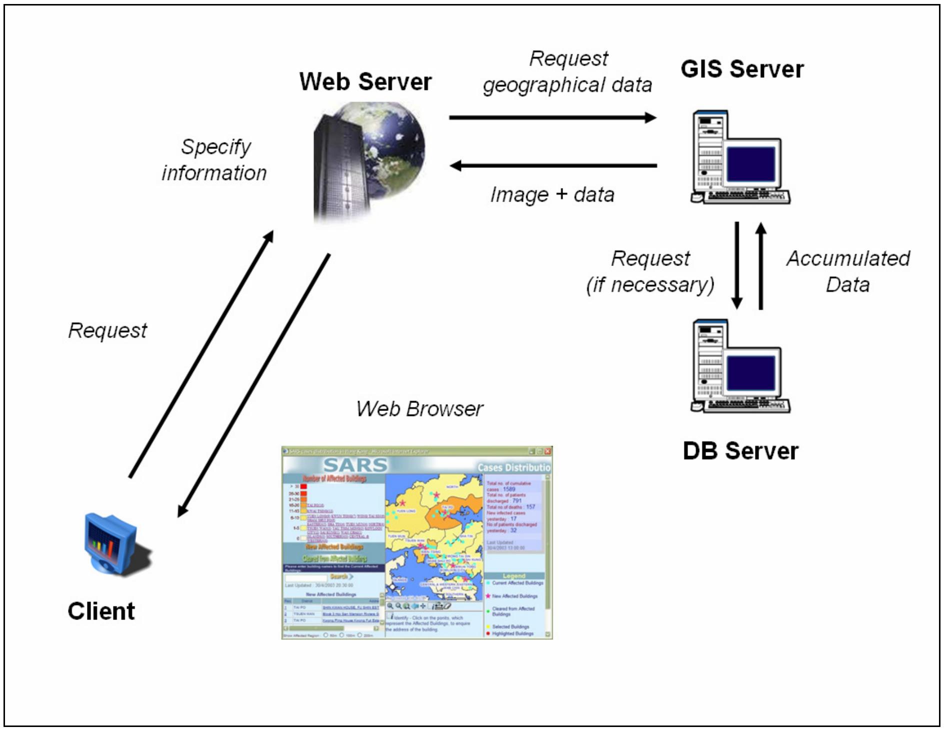

Figure 11 Client/Server Architecture with GIS

As discussed in previous chapters, there is a high probability of limited connectivity after a disaster, especially in rural areas. The network performance of a GIS-enabled Disaster Information Management System is important. There are several client-server architecture options for implementing a GIS. If a central GIS server with a workstation client is used as a solution, there is a need to transfer full data to the workstation. For example, where 1 MB of data may need to be transferred from the server to the workstation, Figure 11 provides an option that makes use of data and an application on the server. While 1 MB of data is needed to generate the information product, the results are transferred from the server to the client as a display only, which reduces the amount of data required for transfer to 100 KB [43]. The following table compares the network times needed for data transfer under various configurations. The transport times required to transfer these data are illustrated for seven standard bandwidth solutions.

Client/Server option	Network traffic transport time (seconds)						
	Wide-area network				Local network		
	56 Kbps	1.54 Mbps	6 Mbps	45 Mbps	10 Mbps	100 Mbps	1 Gbps
GIS server to workstation	893	32.1	8.33	1.11	5.00	0.50	0.005
Web server to browser client	9	0.3	0.08	0.01	0.05	0.005	0.0005

Figure 12 Comparison of network transfer times for various configurations (After ref [43])

From a United Nations perspective for GIS implementation in developing countries, it is noted that the project inputs concentrate on the operating process rather than developing applications to generate convincing decision-making products. UN units set up for GIS, and the teams trained under projects, are often no longer in place a year after the project closes. UN officials emphasize that they need tougher preconditions negotiated with recipient governments prior to the signing of agreements, plus intermittent follow-up supervision and monitoring built into project design [42]. This highlights the importance of host-nation participation in the GIS project for a Disaster Information Management System.

There are several reasons that GIS is not used efficiently, globally, in the disaster management domain. One is that much attention has been paid to technological breakthroughs by satellite-image data providers. Also, those who are working in disaster management have not been actively involved in this field. The high cost and skills required for the application of Geographic Information System (GIS) technology has hindered its utilization for disaster information. Disaster management is required to deal with incidents in the real world. In this regard, GIS has great potential for utilization in emergency situations during disasters, and can be used for evacuation planning as well as the incorporation of satellite information. Nevertheless, GIS has not yet been widely used for the reasons mentioned above [44].

There is an opportunity in the Open Source development environment for building spatially enabled Internet applications for disaster management. For example, PostGIS and PostgreSQL are available software in The Free Software Directory. PostGIS spatially enables the PostgreSQL server, so it can be used as a backend spatial database for a Disaster Information Management System. New features in MySQL the enable GIS use are approaching production-ready release in the near future.

V. CONCLUSION

This research showed that individuals and organizations responding for tsunami relief used many tools to save lives, reduce human suffering and preserve host-nation economic assets after a catastrophic event. Correct and timely information was a critical part of successful disaster management. Not only technical problems, but also political issues related to the disaster management domain impacted the interface among the various militaries, IOs, NGOs and affected countries. Since a lack of experience in that domain created problems during the design phase of the Sahana Disaster Information Management System, was mentioned in Chapter IV, increasing personal knowledge in the disaster management domain is valuable for designing and implementing a Disaster Information Management System. The most experienced organization in disaster relief operations is the United Nations. Therefore, requirements must be obtained from the UN, as well as from critical government sectors such as health.

It was noticed that even though the goal was to match humanitarian needs to resources available from government organizations, non-government organizations and individuals, the appropriate validation of Requests for Assistance (RFAs) was vital. The risk of ignoring validation is the extension of human suffering. The request validation needs to include information about the region, the working humanitarian groups within that region, and the type of support that humanitarian groups could provide but, most importantly, information related to the capability of the host nation's military and civil agencies. It is essential that participants strengthen their capacity to gather, share, analyze and disseminate such information. Therefore, local community participation will increase. A Disaster Information Management System in the host nation will smooth the transfer of missions that have been carried out by military organizations and NGOs, to the host nation agencies. If each country develops its own disaster management IT solution, there will be interoperability problem for NGOs, where they would need to deal with each country depending on its own particular IT system.

It is thought that there are several factors affecting the success of developing and implementing a Disaster Information Management System. Most of them are related to concerns of the affected country's government. One area is ensuring data privacy to address problems with data abuse during disaster situations. Cultural barriers play important roles in creating an information-sharing environment and in the deployment of systems for disaster management. One of the factors increasing the gap between local communities and international organizations is language. In addition to those factors, it must be remembered that limited connectivity affects the collection and dissemination of actionable information. An increase in wireless network coverage in the effected area and effective use of GSM mobile in a Disaster Information Management System will reduce the risks to data collection. Since the cost of sharing information is the driving factor, there is a need for inexpensive hardware and software to develop a Disaster Information Management System.

It is a fact that there are few countries or organizations today that can afford to invest their resources in disaster management when there is no disaster present. This is not only true for poor, developing nations, but also for richer and developed countries. There are always higher priority items that need funding. Since there is a lack of commercial motivation and lack of urgency from governments, a workaround for those issues to get people form various professions to create a universal Disaster Information Management System is to use the "Open Source" approach. This also helps Localization, which increases the participation of the host-nation community. Finally, a geographic information system (GIS) can provide correct and timely information. There is an opportunity to use free software to create a GIS solution in the disaster management domain. Design and implementation of such a system will create a level of collaboration that involves participants working as a team to achieve a common goal.

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